(19) [logo] Europäisches Patentamt
European Patent Office
Office européen des brevets

[barcode]

(11) **EP 0 911 792 A2**

(12) # EUROPEAN PATENT APPLICATION

(43) Publication date:
April 28, 1999 Patentblatt 1999/17

(51) Int. Cl.^{6}: **G09G 3/36**

(21) Filing number: **98117971.6**

(22) Filing date: **September 22, 1998**

(84) Designated Contracting States:
AT BE CH CY DE ES FI FR GB GR IE IT LI LU MC NL PT SE

Designated Application States:
AL LT LV MK RO SI

(30) Priority: **October 22, 1997 DE 19746576**

(71) Applicant/Applicant(s):
- **Carl Zeiss**
  89518 Heidenheim (Brenz) (DE)
  Designated Contracting States:
  CH DE ES FR IT LI NL AT
- **CARL-ZEISS-STIFTUNG, trading as CARL ZEISS**
  89518 Heidenheim (DE)
  Designated Contracting States:
  GB

(72) Inventor: **Wesemann, Wolfgang**
50996 Cologne (DE)

(54) **Method for generating an image on a color display and suitable color display**

(57) The invention pertains to a method for generating an image on a color display with an addressing device, whereby three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns.

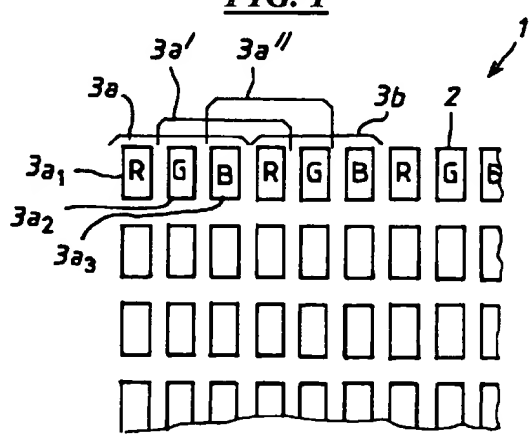
According to the invention, a visible image point is generated on the color display by the addressing device of the color display by means of three adjacent color regions of different, adjacent pixels.

In a further method according to the invention, one or more image regions that are to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift on the display, the various pixels are addressed by the addressing device in such a way that a predetermined shift of the effective image region to be displayed takes place.

In the color display according to the invention with an addressing device, three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns.

According to the invention, the addressing device of the color display is constructed in such a way that a visible image point is generated on the color display by means of three adjacent color regions of different, adjacent pixels, and/or one or more image regions that to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift, a shift of the effective image region to be displayed takes place.

FIG. 1



EP 0 911 792 A2

[*page 2, column 1*]

Description

[0001] The invention pertains to a method for generating an image on a color display with an addressing device, whereby three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns, and to a color display suitable for implementing the method.

[0002] With the color displays that are common at the present time, the images are built up from individual pixels that are arranged in a matrix. These color displays are called matrix displays.

[0003] A pixel is understood to be a point on a display that is defined by its line and column numbers and can emit in color or achromatically. In the case of a color monitor, each pixel is comprised of three color pixel sections (color regions), which usually emit in the three primary colors red, green and blue. The color pixel sections are either adjacent color rectangles or color circles in a hexagonal arrangement.

[0004] A color display of such a type can be used for vision testing instruments, whereby the resolution is often a restrictive element.

[0005] A large number of different aids or instruments are presently being used, particularly by eye doctors and opticians, for refraction and for vision tests. They include vision test charts, optotype projectors, transmitted light vision testing instruments and computerized vision testing instruments.

[0006] Of course, with a printed vision test chart, only the tests they have been designed for can be carried out.

[0007] With optotype projectors and transmitted light vision testing instruments, the optotypes can be changed. Binocular function tests are possible as well if suitable accessories are used.

[0008] Beyond that, a vision test using a computer permits testing of visual capability functions that previously would have required several special vision test charts or specially equipped vision testing instruments.

[0009] The vision test pursues the goal of determining just noticeable differences, which can be regarded as a measure of the capability of the visual system. For that purpose, vision testing instruments feature optotypes in graduated stimulus strengths. The optotype type is based on the vision function to be tested. For example, letters in graduated sizes are used to test acuteness of vision.

[page 2, column 1 cont.]

[0010] The demands on vision testing instruments that are to be used for testing just noticeable differences are not the same as the other requirements. For example, to test three-dimensional vision (stereoscopic vision), synthesized stereoscopic images are used that have various differences in depth where individual components of the image appear to float in front of the observation plane. The result of these tests is the size of the smallest letter that can still be recognized, or the size of the smallest three-dimensional difference in depth that can still be seen. These values characterize the physiological just noticeable differences of the eye being examined.

[page 2, column 2]

[0011] To be able to measure physiological just noticeable differences, it must be possible to display optotypes with stimulus strengths that are of the same order of magnitude as the just noticeable difference. An accurate measurement of the just noticeable difference additionally requires that

a) the step size by which the stimulus strength can be altered is as small as possible, and that

b) it is also possible to display stimulus strengths that are smaller than the sensory physiology just noticeable difference value.

[0012] People with visual health have two eyes, and thus have the capability for binocular vision, which is a basic requirement for three-dimensional depth perception.

[0013] A distinction is made among three stages of binocular vision:

a) simultaneous vision with both eyes without fusion (fusion = the ability to fuse the two monocular visual impressions in the visual cortex),

b) simultaneous vision with both eyes with fusion, and

c) simultaneous vision with both eyes with stereoscopic vision (stereoscopic vision means the same as stereopsis or laterally disparate three-dimensional vision).

[0014] A necessary prerequisite for stereoscopic vision is the sensory fusion of the image impressions of both eyes in the brain. A "living" three-dimensional visual impression results from stereoscopic vision.

[0015] Stereoscopic vision is based on the fact that the two human eyes observe surroundings from two different viewing directions. As a result, when a 3-dimensional object is observed, retinal images are produced that are not exactly the same in both eyes, but instead – because of the different viewing directions – they have horizontally displaced components.

[0016] For example, if a pair of eyes fixes on object point O at a distance a, this object point is reproduced in the fovea of both eyes. By contrast, a second point P that is placed in front of this object point will no longer be reproduced on corresponding retinal locations, but instead will be to the right of the fovea in the left eye and the left of the fovea in the right eye. The horizontal offset of the two images of P relative to one another is called "lateral disparity". "Stereoscopic angle" is used as the measure of the size of the lateral disparity.

[0017] The exact interrelationship among stereoscopic angle, object distances and pupil spacing is described in the Handbuch für Augenoptik *[Handbook of Ophthalmic Optics]*, published by the firm of Carl Zeiss, 73447 Oberkochen, newly revised by Dr. Helmut Goersch, 3rd Ed., 1987, pp. 87-92.

[0018] The smallest stereoscopic angle that leads to stereoscopic vision is called the "stereoscopic critical angle." It is a measure of the just noticeable difference of stereoscopic vision, and is approximately 10 seconds of an angle for photopic human vision. If this just noticeable difference is to be determined accurately, it requires vision testing instruments that can generate three-dimensional optotypes with stereoscopic angles of less than 10 seconds of an angle.

[0019] The capability for stereoscopic vision has to be distinguished from the monocular ability to estimate three-dimensional depth. Only people with intact binocular vision have stereoscopic vision capability, while the distance to an object can also be estimated by those who do not have that capability, e.g., functionally monocular people. These people can estimate three-dimensional depth by means of additional visual information, such as the size of the retinal image, object overlaps, light, brightness, shadows and motion parallax.

[0020] The requirement profile for a universal vision testing instrument includes the following points:

[0021] The various kinds of optotypes – letters, numbers, Landolt rings, and the Snellen E Chart – to name only the most important, must be displayable by a universal vision testing instrument. Displayable in various sizes and formations for a range of visual acuity requirements between 0.05 and 2.0. In addition, symbols such as rectangles, circles, crosses and half-fields should be available for special vision tests.

[0022] Of course, it should also be possible to modify all of the optotypes in contrast and color so that color vision tests and a test of vision at low contrasts can be carried out. It is also advantageous if moving optotypes can be displayed as well.

[0023] Graphical displays should be possible supplementally, and the display of images is desirable in order to increase the attention of children during the vision test.

[0024] Naturally, the test field in which the optotypes are presented must also satisfy various requirements. Primarily, the light quality should match natural conditions as closely as possible, i.e., it must be free of flicker and have a light color that is similar to sunlight. In order to open up new dimensions in vision testing, it should be possible to vary the test field in color and brightness.

[0025] The presentation of the optotypes must be variable, i.e., in groups or individually, with or without randomly controlled variation.

[0026] Another important point is the testing of binocular vision and stereoptical vision. Doing this requires a technical arrangement that provides the option of presenting different visual impressions to the two eyes. The best method of presentation is acknowledged to be a simultaneous, separate presentation of the optotypes for the right and left eye in the same vision field, in brief, "through simultaneous separation of the visual impressions". These are the requirements to be placed on a universally applicable vision testing instrument.

[0027] New methods for improving the display of the optotypes are additionally subject to the secondary condition that as little as possible will need to be changed on the known (color) display, since it involves a special application of the displays, and for this special application one would like to draw upon commercially available color displays, which are produced in large quantities, so that the vision testing instruments need not be unnecessarily expensive.

[0028] The test methods known at the present time for testing stereoptic vision are modern versions of the Wheatstone stereoscope that was first introduced in the previous century. In this type of presentation, the left and right eye are shown different two-dimensional images by means of a suitable image-dividing instrument. These two images show the three-dimensional object as it would be seen by the two eyes from the different viewing directions. The two partial images show image portions that have been shifted in a lateral disparate manner. During the sensory fusion of the two partial images, the visual system reconstructs the three-dimensionality of the displayed object.

[0029] Until a short time ago, primarily used as commercial stereoscopic tests were printed test images in which the laterally disparate shift of the three-dimensional image portions were realized by means of printing technology. More recently, vision test methods have been introduced in which the test image is shown on a monitor or LCD display. However, the problem with this display method is that the lateral disparity is not continuous – as with the print method – but can only be changed in discrete steps in units of pixel width.

[0030] The increments at which the lateral disparity can be changed results from the number of image points that can be displayed in one line on the monitor. For example, if an LCD display with a pixel width of 0.33 mm is being used, the smallest realizable stereoscopic angle and the increment from a distance of 5 meters is equal to arctan (0.33 mm / 5000 mm) = 13.6 seconds of an angle. It is obvious that this is not adequate to register a stereoscopic critical angle of 10 seconds of an angle accurately by means of measuring technology.

Therefore, an accurate determination of the stereoscopic critical angle cannot be carried out with present-day commercially available monitors. For that reason, new methods must be developed by means of which the positioning accuracy of image components on a matrix display can be improved.

[0031] It is the task of the invention to develop, for generating an image on a color display that is known in the art, methods that allow images to be more accurately positioned than in the past.

[0032] This task is solved through a method according to the characterizing portion of the first or second patent claim, as well as through a color display according to the characterizing portion of the eighth patent claim.

[0033] The methods according to the invention improve the horizontal positioning accuracy of image regions on a color display with an addressing device. The methods are especially well-suited for generating three-dimensional images, i.e., for testing stereoscopic vision.

[0034] The invention thus pertains to methods for generating an image on a color display with an addressing device, whereby three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns.

[0035] According to the invention, a visible image point is generated on the color display by an addressing device of the color display by means of three adjacent color regions of different, adjacent pixels, (in this regard, the fixed allocation of the three color regions to a specific, spatially fixed pixel is suspended in favor of a variable allocation of the color regions to a pixel with a position that is determined through the selection of the color regions that make up the pixel), or one or more image regions to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift on the display, the color regions of the pixels are addressed by the addressing device in such a way that the predetermined shift of the effective image region to be displayed takes place.

[0036] The color display that is needed for carrying out the method according to the invention is distinguished according to the invention in that the addressing device of the color display is constructed in such a way that

1) an image point is generated on the color display by means of three adjacent color regions of different, adjacent pixels,

and/or

2) one or more achromatic or color image regions that are to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift, a shift of the effective image region to be displayed takes place.

[0037] Per the state of the art, the smallest shift of an image that can be generated with a matrix display is determined by the width of a pixel. In the case of the TFT *[thin film transistor]* displays presently being used in the POLATEST E, the width of a pixel is 0.33 mm. This results in a minimum stereoscopic angle of 13.6 seconds of an angle at 5 meters.

[0038] The horizontal image resolution is improved in both of the methods according to the invention. The methods according to the invention are especially well-suited for a vision testing instrument. They are distinguished in that by means of an addressing device of the color display, one or more image regions on the display can be positioned more accurately than before. In the first method, the horizontal positioning of image regions takes place with an accuracy of 1/3 of a pixel through the addressing of the color regions of different, adjacent pixels, and in the second method, with any desired accuracy through a shift of the effective light in the light distribution that is present in the image regions.

[0039] To do that with a known color display, however, only the addressing device of the color display has to be altered in order that the method according to the invention can be used. The adaptation of the addressing device can be carried out by means of hardware or software, depending on the construction of the particular addressing device in question.

[0040] By using the methods according to the invention, one thus obtains a color display with higher positioning accuracy that can advantageously be used in particular for measuring the just noticeable difference of stereoscopic vision.

[0041] The color display is preferably a TFT display on which a strip polarizer has been mounted, so that the stereoscopic perception can be tested by having the person to be tested wear polarizing glasses in which each of the two eyes is provided with a polarization axis that is perpendicular to that of the other eye. However, other displays and separating methods that allow various partial images to be presented to the right and left eyes can be used as well.

[0042] All of the information furnished in DE 41 15 145 ad DE 94 13 371 for the vision testing instrument described therein are also analogously applicable to the vision testing instrument according to the invention, whereby the furnished information also is also analogously applicable to the color display according to the invention.

[0043] The invention is explained in more detail below with the aid of an embodiment and references to the attached Figures, whereby the following example does not have a concluding

character for the invention, and includes additional advantageous further developments of the invention.

[0044] Shown are:

Figure 1, a detailed view of a TFT display;

Figure 2, a partial view of a TFT display; and

Figure 3, the light intensity along a region of a line that is intended for the right eye of an observer in accordance with the second method according to the invention; and

Figure 4, the light intensity along a region of a line that is intended for the left eye of an observer (in accordance with the second method according to the invention).

[0045] The methods according to the invention are described below using the POLATEST E vision testing instrument, for which protection rights DE 41 15 145 and DE 94 13 371 exist and by means of which as many vision capability tests as possible can be carried out with a single vision testing instrument.

[0046] A universally applicable vision testing instrument meets all of the requirements for refraction, as well as for vision testing and displaying of vision functions. Of course, as a basic principle this universal vision testing instrument offers the possibility of accommodating new methods of vision capability testing.

[0047] The solution found in DE 94 13 371 – known by the trade name POLATEST E vision testing instrument – will additionally be presented in two steps, and meets all of the requirements placed above.

[0048] For the presentation of optotypes for which no separation of the visual impressions is to be made for the right and left eyes, flat-panel color displays as used in laptop computers meet all of the previously mentioned requirements for optotype presentation.

[0049] The optotypes are generated electronically in a graphics format of 640 x 480 pixels in accordance with the present state of the art for flat-panel color displays. This allows the presentation of optotypes up to a visual acuity requirement of 2.0 at a test distance of more than 4 meters. Round optotypes can also be displayed well if rounding algorithms are used.

[0050] The high vision test demands placed on the test field – light quality that corresponds as closely as possible to natural conditions and is flicker-free – can be realized with new kinds of compact fluorescent lamps in electronic high-frequency operation. They have the advantage that they do not flicker, neither during lamp startup nor during operation. In addition, they offer high light power and an energy spectrum that is similar to sunlight.

[0051] In the case of the graphics flat-panel color display that is used and the described transillumination, presentation is only a question of the design of the addressing, i.e., the software.

[0052] Display in groups or individual presentation, randomly controlled repetition, rapid change of optotypes, moving optotypes and additional variants are therefore relatively easy to realize, even in combination with variable contrast and in various colors.

[0053] However, an additional element is needed for the simultaneous separation of the visual impressions.

[0054] In order to be able to present in a comprehensible way the solution that was found for the task, we will first discuss below the functional principle of flat-panel color displays, specifically, the so-called "active matrix display" or "TFT LCD" that is used in the POLATEST E vision testing instrument.

[0055] Flat-panel color displays are comprised of a number of liquid crystal elements in which the electro-optic effect of liquid anisotropic crystals is used for light control. These liquid crystals can be oriented in a preferred direction by means of electrical fields. The anisotropic properties of the crystals that have been oriented in this way causes polarized light to be weakened, blocked completely or allowed through, depending on its polarization direction.

[0056] These states are realized in the following way: Orientation layers are applied in such a way to the liquid crystal cells that the longitudinal axes of the molecules, which contact the left and right glass surfaces, are rotated by 90 degrees to each other in the off state. Because the molecules attempt to align themselves parallel to each other in the liquid crystalline layer, their preferred direction between the two glass surfaces rotates by 90 degrees. The liquid crystals array themselves as if in a twisted tape.

[0057] The polarization filters are arranged in such a way that their transmission direction coincides with the preferred direction of the longitudinal axes of the molecules at the two glass surfaces. The polarized light that passes through allows itself to be guided by the liquid crystal molecules, and follows their twisted structure in such a way that its plane of oscillation after passing through the layer at the other delimiting surface has been rotated by a total of 90 degrees. Since it is thus oriented parallel to the second polarization filter, light can exit unimpeded from the liquid crystal cell. The liquid crystal cell is translucent; it appears bright.

[0058] It behaves differently if a voltage is present at the two electrodes of the liquid crystal cell. Then, the liquid crystal molecules have a tendency to rotate their longitudinal axes in the direction of the field; if the voltage is large enough, they all position themselves perpendicular to the glass surfaces, except in a narrow transition region. As a result, the polarization plane of the

light is no longer rotated as it passes through the layer – the second polarization filter becomes an impenetrable obstacle. The liquid crystal cell is opaque; it appears dark.

[0059] Many such cells placed alongside each other yield a graphics flat-panel color display with 640 x 480 = 307,200 pixels. The structure of such a graphics-capable flat-panel color display (1) is shown schematically in Figures 1 and 2.

[0060] In turn, each pixel (3a) is comprised of red, green and blue color regions (or pixel parts) (3a1, 3a2, 3a3), which individually act like a red, green and blue light valve. Depending on their electronic addressing, they allow more or less red, green and blue light through.

[0061] They are addressed by means of an electronic control element (transistor) that is mounted directly on the light valve. In a macrophotograph (diameter = 1 mm), they can be seen in the top left corner of each light valve. The conductive pathways to the electronic control unit are also visible in the form of dark bands.

[0062] Taken together, the three color regions (3a1, 3a2, 3a3) red/green/blue give the visual impression of a color pixel (3a) with a size of 0.33 mm x 0.33 mm. When viewed from 4 meters away, each individual color pixel (3a) has a viewing angle of 0.28 angular minutes. Since the resolving power of the eye is always worse than 0.5 viewing angle minutes, from a distance of 4 meters the 307,200 color pixels (3a, 3b) of the 16 x 21 cm display (1) thus create an image impression that appears continuous.

[0063] For the simultaneous presentation of optotypes for binocular testing, a special filter that simultaneously polarizes in alternating lines the visual impressions for the right and left eyes is mounted in front of the flat-panel color display. This special filter must be accurately adjusted to the element structure of the display in order to ensure a clean separation between the images for the left and right eyes. The material that is used for this special polarizer is the same one that has long been used in the Polatest vision testing instrument for the random dot tests. With this accessory, simultaneous presentation of optotypes with positive polarization is realized.

[0064] For both types of presentation – with and without separation of the visual impressions – the addressing and the generating of the tests is carried out with the most modern computer technology, which measures up to the requirements for rapid imaging of the optotypes.

[0065] In this special example, the heart of this addressing is a CYRIX 486SLC microprocessor that runs at a clock speed of 33 MHz. A graphics controller that has been especially matched to this flat-panel display (1) is needed for addressing the LCD display (1).

[0066] Both components are realized for the smallest space in the latest industry standard, the so-called PC/104 format. The computing power of an entire 486/33 MHz computer is thus compressed to 96 x 90 x 35 mm.

[page 6, column 10]

[0067] Preferably, PCMCIA flash cards are used as the data storage for the optotypes. They have numerous advantages over the hard drives that are normally used as mass storage:

Rapid access times,

Not sensitive, since there are no moving mechanical parts at all,

Software updates through simple exchange of cards,

Smaller, and

Less power consumption.

[0068] The range and the selection of the optotypes take place by means of infrared remote control.

[0069] The question posed at the beginning with regard to the technology for a universally applicable vision testing instrument has been answered by the presented combination of a translucent, electronically controlled flat-panel color display (1) with a special polarizer produced through high-precision manufacturing. Refraction and visual capability testing can thus be carried out with no restrictions.

[0070] A summary of the range of capabilities of the POLATEST E vision testing instrument is described briefly below.

[0071] The 16 x 21 cm test field (1) in which the optotypes are presented has a luminance of just over 300 cd/m*[^{2}] [candela/square meter]* and a light color that is similar to sunlight with a color temperature of 4,000 degrees K. The contrast of the dark optotypes on the light test field is 97%. The brightness of the test field (1) and the optotypes can be changed independently of each other in 32 stages. As a result, an inverse display of the optotypes (light on a dark background) is possible, for example.

[0072] The contrast of the optotypes can be adjusted in 32 gray stages, while the test field and the optotypes can be varied in color (32,768 colors) and brightness, thus opening new dimensions in vision testing.

[0073] Different types of optotypes – letters, numbers, Landolt rings, Snellen E and children's optotypes – can be selected and displayed in different sizes for a range of visual acuity requirements between 0.05 and 2.0. In terms of the type of presentation, a choice can be made between group display (one or more lines of different visual acuity requirements) and individual presentation. Image change takes place within 0.5 seconds. The sequence of the images can be set individually, e.g., for refraction, in which a fixed sequence optotypes is advantageous. Numerous special tests for the widest possible variety of function tests are available.

[page 7, column 11]

[0074] The visual acuity determination can be performed according to standards with Landolt Rings and letters. The possibility of being able to choose between group presentation and individual presentation with a predetermined and/or randomly controlled optotype sequence can be considered as a special feature.

[0075] Binocular refraction is carried out using simultaneous positive polarization separation of the visual impressions. All of the customary systems of binocular functional testing can be realized with this technique. Available at the present time are the optotypes of the measuring and correction methodology per H.J. Haase (MKH), equalization tests and elements of graphical analysis are available.

[0076] Special mention should be made here of the fact that it was possible for the first time to realize the justified claim of a same-size retinal image for optotypes at different test distances. Previously in the Polatest vision testing instrument, the optotypes had the originally developed retinal dimensions only at a test distance of 5.5 meters.

[0077] This vision testing instrument makes possible a large number of additional applications. It is universally applicable, and thus opens up a wide area for interdisciplinary cooperation in the further development of visual capability testing. Such further developments are making no changes at all to the POLATEST E vision testing instrument itself. Only the software and/or the addressing of the display have to be suitably supplemented if the method according to the invention is to be used.

[0078] In the vision testing instrument according to the invention, the generating of the stereoscopic image pair takes place in that the partial image for the right eye is displayed by the odd-numbered symbols *[sic]* of a TFT display, and the partial image for the left eye is displayed by the even-numbered lines (4a, 4b). For the observer, the partial images for the right and left eyes are separated by a strip polarizer in front of the TFT display and suitably polarized eyeglasses.

[0079] To generate the three-dimensional visual impression, the portions of the image that are supposed to lift from the display three-dimensionally are shifted to the side (lateral disparity) by a specific amount in one of the two partial images.

[0080] The color display needed for carrying out the first inventive method must have an addressing device in which each pixel is preferably made up of three adjacent color rectangles (e.g., with the three primary colors red, green and blue).

[0081] The addressing device of the color display must be constructed in such a way that the color pixel parts can be addressed on the color display independently of each other.

[*page 7, column 11 cont.*]

[0082] The first method is based on the fact that each pixel (Figure 1 with 3a) of the TFT display is made up of three narrow, adjacent color rectangles (3a1, 3a2, 3a3) that emit in the primary colors red, green and blue. Each of these rectangles (3a1, 3a2, 3a3) is approximately 0.11 mm wide and 0.33 mm high.

[0083] Since nearly achromatic stereoscopic images are required for the eye test, the increment of the lateral shift of image regions can be reduced through the fact that the image points are not displaced by a whole number of pixels (e.g., by displacing the RGB color triple at 3a by one pixel width to 3b), but rather in steps of 1/3 pixel. If, for example, an image point at 3a is to be shifted by 1/3 of a pixel, the red color rectangle (3a1) at the left is extinguished and an red color rectangle (3b1) is added at the right side. As a result, the RBG *[sic]* pixel (3a) becomes a BGR *[sic]* pixel (3a').

[0084] The distinguishing characteristics of the new method are

a) that the image points on the display can be shifted by less than a pixel width, and

b) that the minimum realizable stereoscopic angle is not limited by the pixel width, but can instead be reduced to a third of the usual value, and

c) that image points on the display can be shifted in steps of one third of the pixel width.

[0085] With the first new method according to the invention, it is thus possible to reduce the minimum shift of parts of the image by a factor of 3 versus the present value. Thus, a minimum lateral disparity of 4.54 arc seconds can be achieved from a distance of 5 meters with the Polatest E by using the method according to the invention.

[0086] By means of another method, the positioning accuracy of image regions on the display can be improved as well.

[0087] The color display needed for carrying out the second inventive method must have an addressing device that makes possible the generating of a shift of the effective light distribution of an image region to be displayed.

[0088] In this method, the vision objects should not be individual points, but rather a light distribution comprised of more than one pixel. For the sake of clarity, it is assumed in Figure 3 that a narrow vertical bar of light with Gaussian light distribution in the horizontal cross section is to be presented to the left eye. This light distribution will be approximated on the display by means of the light intensities at the sampling points that are predetermined by the pixels. Because of its ability to integrate, the visual system is able to localize the position of this effective light distribution very accurately. Now, in order to generate a laterally shifted bar of light for the right eye, the addressing device must calculate the light intensities of a Gaussian curve with effective light that is correspondingly shifted, and display them as a partial image for the right eye. Using this method, image displacements can be generated that are as small as desired and that are appropriately localized by the ability of the visual system to locate the effective light and are converted with a haploscopic presentation into a corresponding three-dimensional visual impression.

[0089] Shown in Figures 3 and 4 is this method for shifting the Gaussian light curve along a line, whereby the light intensity for the right eye is shown in Figure 3, the light intensity for the left eye in Figure 4. The light intensity is entered on the vertical axis and the position of a pixel on the horizontal axis, whereby one scale division corresponds to the size of a pixel. The distribution of the light intensity in Figure 4 is displaced versus Figure 3, so that the effective light is shifted to the right by 1/3 of the pixel width.

[0090] As is documented by these two Figures 3 and 4, a relocation of the effective light, and thus a lateral shift of the region, can be effected for a optotype simply by means of a change in the light intensity at the sampling points that are predetermined by the position of the pixels.

[0091] This second method, either alone or in combination with the first method, also improves the measuring method for determining the stereoscopic critical angle.

[0092] The second method is not limited to color displays, rather, it can also be used on a black/white display.

[0093] With the second method, the positioning accuracy of image components is increased substantially not only in the horizontal direction, but also in any other desired directions. For testing stereoscopic vision, however, only the improvement of horizontal resolution is relevant.

[0094] The first method is well-suited for the 3-dimensional display of optotypes that consist of small dots or lines, such as random-dot stereograms, for example. With this method, however, the increment is limited to an image shift of 1/3 of the pixel width.

[0095] The second method is preferably suitable for somewhat broader light distributions, but it does have the advantage that positioning accuracy can be achieved with practically as much accuracy as desired, and a shift is possible in all directions.

[0096] The methods according to the invention are not limited to TFT displays (1), but can also be used with other vision testing instruments that work with conventional television monitors. Monitors that use Sony Trinitron picture tubes have a RGB strip mask similar to the TFT display, in which each image point is made up of three adjacent color rectangles. Eizo monitors also use a similar pixel structure. These methods can even be applied to simple color television monitors that have a hexagonal image point matrix.

[page 8, column 14]

[0097] If a strip polarizer cannot be mounted over a television monitor, however, then other separating methods have to be used for the haploscopic presentation, such as, for example, alternating image presentation for the left and right eyes by means of LCD shutter glasses.

Patent Claims

1. Method for generating an image on a color display with an addressing device, whereby three color regions (3a1, 3a2, 3a3) that are placed next to each other and emit different colors are assigned to each pixel (3a), and the pixels (3a, 3b) are arranged in lines (4a, 4b) and/or columns (5a, 5b), characterized in that a visible image point (3a') is generated on the color display (1) by the addressing device of the color display (1) by means of three adjacent color regions (3a2, 3a3, 3b1) of different, adjacent pixels (3a, 3b).

2. Method for generating an image on a color display with an addressing device, whereby the pixels (3a, 3b) are arranged in lines (4a, 4b) and/or columns (5a, 5b), characterized in that one or more image regions that are to be displayed are formed from more than one pixel (3a, 3b), whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift on the display, the various pixels (3a, 3b) are addressed by the addressing device in such a way that a predetermined shift of the effective image region to be displayed takes place.

3. Method according to Claim 2, characterized in that the total intensity of the shifted light distribution is equal to the total intensity of the non-shifted light distribution.

4. Method according to Claim 1, characterized in that the method according to Claim 1 is combined with the method according to Claim 2.

5. Method according to one of the Claims 1-4, characterized in that each eye is presented with a separate partial image.

6. Method according to one of the Claims 1-5, characterized in that the display is used in a vision testing instrument.

7. Method according to Claim 6, characterized in that the image region or regions to be displayed are optotypes.

8. Method according to one of the Claims 6 or 7, characterized in that the vision testing instrument is used to measure the just noticeable difference of stereoscopic vision per DIN 5340 of the visual system of a person to be examined, whereby defined image regions are presented at a prespecified distance.

9. Color display with an addressing device, whereby three color regions (3a1, 3a2, 3a3) that are placed next to each other and emit different colors are assigned to each pixel (3a, 3b), and the pixels (3a, 3b) are arranged in lines (4a, 4b) and/or columns (5a, 5b), characterized in that the addressing device of the color display (1) is constructed in such a way that a visible image point (3a') is generated on the color display (1) by means of three adjacent color regions (3a2, 3a3, 3b1) of different, adjacent pixels (3a, 3b), and/or one or more image regions that to be displayed are formed from more than one pixel (3a, 3b), whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift, a shift of the effective image region to be displayed takes place.

10. Color display according to Claim 9, characterized in that the color display (1) is a TFT display.

11. Color display according to one of the Claims 9 or 10, characterized in that a strip polarizer is mounted over the color display (1).

12. Color display according to one of the Claims 9-11, characterized in that a pixel (3a) is comprised of three adjacent color rectangles (3a1, 3a2, 3a3) with the three primary colors red, green and blue.

13. Color display according to one of the Claims 9-12, characterized in that a quarter-wave film is mounted on the display (1) in front of or behind the polarization film.

14. Color display according to one of the Claims 9-13, characterized in that the color display (1) is part of a vision testing instrument.

[page 9, column 16]

15. Color display according to Claim 14, characterized in that color optotypes can also be displayed on the display (1) of the vision testing instrument.

16. Color display according to one of the Claims 14 or 15, characterized in that moving optotypes can also be displayed in the display (1) of the vision testing instrument.

17. Color display according to one of the Claims 14-16, characterized in that the color display is part of a vision testing instrument in which optotypes are presented at a prespecified distance in order to measure a three-dimensional just noticeable difference of the visual system of a person to be examined.

FIG. 1

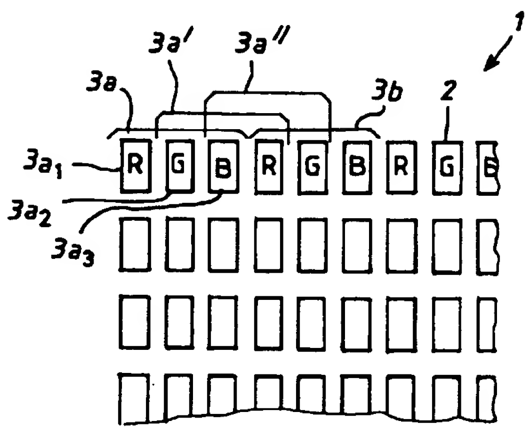


FIG. 2

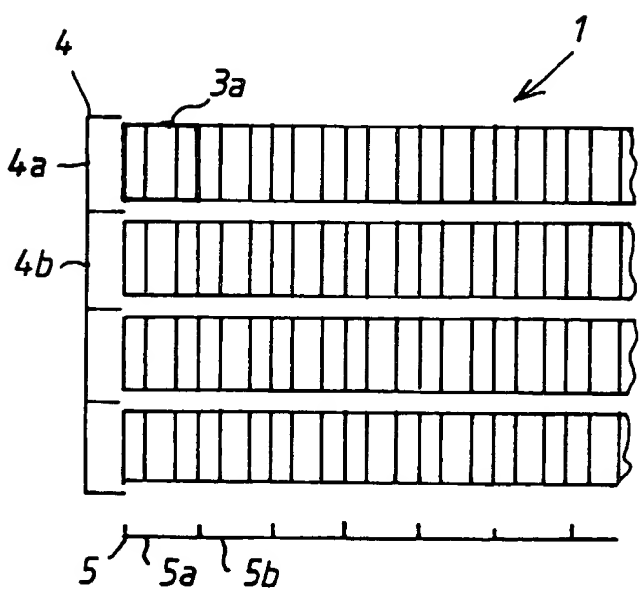


FIG. 3

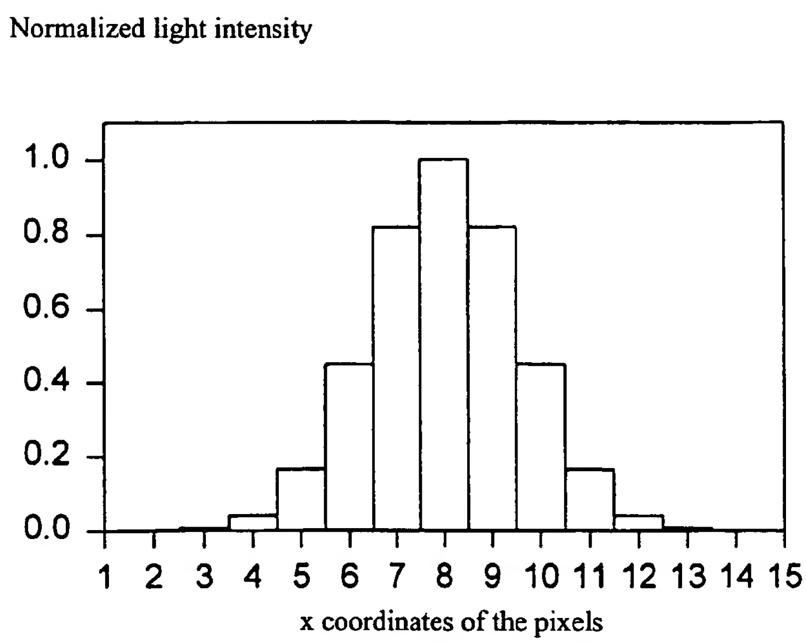
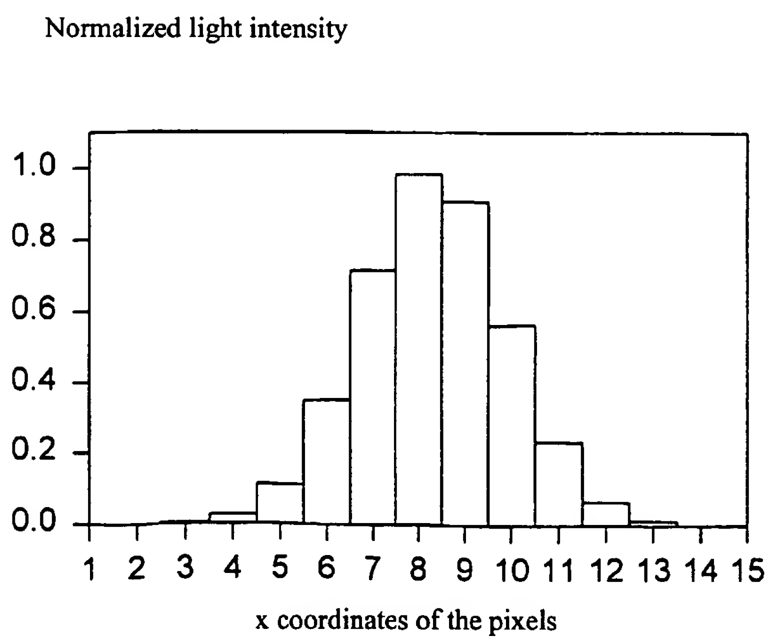

Normalized light intensity
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
x coordinates of the pixels

FIG. 4


Normalized light intensity
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
x coordinates of the pixels

(19) [logo] Europäisches Patentamt
European Patent Office
Office européen des brevets

[barcode]

(11) **EP 0 911 792 A2**

(12) # EUROPEAN PATENT APPLICATION

(43) Publication date:
March 22, 2000 Patentblatt 2000/12

(51) Int. Cl.^{7}: **G09G 3/36**

(21) Filing number: **98117971.6**

(22) Filing date: **September 22, 1998**

(84) Designated Contracting States:
AT BE CH CY DE ES FI FR GB GR IE IT LI LU MC NL PT SE

Designated Application States:
AL LT LV MK RO SI

(30) Priority: **October 22, 1997 DE 19746576**

(71) Applicant/Applicant(s):
- **Carl Zeiss**
  89518 Heidenheim (Brenz) (DE)
  Designated Contracting States:
  CH DE ES FR IT LI NL AT
- **CARL-ZEISS-STIFTUNG, trading as CARL ZEISS**
  89518 Heidenheim (DE)
  Designated Contracting States:
  GB

(72) Inventor: **Wesemann, Wolfgang**
50996 Cologne (DE)

(54) Method for generating an image on a color display and suitable color display

(57) The invention pertains to a method for generating an image on a color display with an addressing device, whereby three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns.

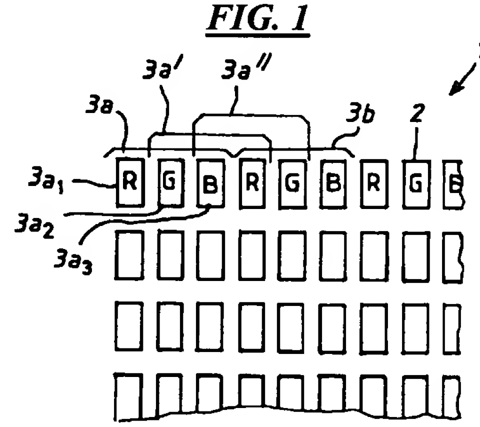
According to the invention, a visible image point is generated on the color display by the addressing device of the color display by means of three adjacent color regions of different, adjacent pixels.

In a further method according to the invention, one or more image regions that are to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift on the display, the various pixels are addressed by the addressing device in such a way that a predetermined shift of the effective image region to be displayed takes place.

In the color display according to the invention with an addressing device, three color regions that are placed next to each other and emit different colors are assigned to each pixel, and the pixels are arranged in lines and/or columns.

According to the invention, the addressing device of the color display is constructed in such a way that a visible image point is generated on the color display by means of three adjacent color regions of different, adjacent pixels, and/or one or more image regions that to be displayed are formed from more than one pixel, whereby the image regions to be displayed possess an effective light distribution, and that for an image region shift, a shift of the effective image region to be displayed takes place.

FIG. 1



EP 0 911 792 A3

European
Patent Office

EUROPEAN SEARCH REPORT

Number of the Application
EP 98 11 7971

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to Claim	CLASSIFICATION OF APPLICATION (Int. Cl. 6)
X A	US 5 113 274 A (TAKAHASHI SEIKI ET AL) May 12, 1992 (1992-05-12) * The entire document * - - -	1 4-10	G09G3/36
X A	EP 0 273 995 A (HOSIDEN ELECTRONICS CO) July 13, 1988 (1988-07-13) * Abstract * * Column 9, Line 22 – Line 35 * * Figure 13 * - - -	1 4-10	
X A	EP 0 738 089 A (HITACHI ELECTRONICS) October 16, 1996 (1996-10-16) * Abstract * * Column 24, Line 11 – Column 25, Line 33 * * Figures 18, 19 * - - -	1 4-10	
A	FR 2 742 910 A (THOMSON MULTIMEDIA SA) June 27, 1997 (1997-06-27) * Abstract * * Page 2, Line 20 – Page 3, Line 10 * * Page 4, Line 27 – Page 11, Line 14 * * Figures 4-9 *	1, 4-10	FIELD OF SEARCH (Int. Cl. 6) G09G

~~The present search report has been drawn up for all claims.~~

Place of search	Date of completion of the search	Examiner
THE HAGUE	November 5, 1999	Cochonneau, O

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document	T: theory or principles underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons -- &: member of the same patent family, corresponding document

European
Patent Office

Number of the Application
EP 98 11 7971

PATENT CLAIMS SUBJECT TO FEES
The present European Patent Application contained more than ten patent claims when submitted. [ ] Only a portion of the claim fees was paid within the prescribed period of time. The present European Search Report was created for the first ten patent claims, as well as for those patent claims for which the claim fees were paid, namely, patent claims: [ ] None of the claim fees was paid within the prescribed period of time. The present European Search Report was created for the first ten patent claims.
LACK OF UNIFORMITY OF THE INVENTION
In the opinion of the Search Department, the present European Patent Application does not meet the requirements for uniformity of the invention, and contains several inventions or groups of inventions, namely: See Supplemental Page B [ ] All additional search fees were paid within the prescribed period of time. The present European Search Report was created for all patent claims. [ ] Since it was possible to carry out with no expenditure of labor the search for all searchable claims that would have justified an additional search fee, the Search Department has not demanded payment of such a fee. [ ] Only a portion of the additional search fees was paid within the prescribed period of time. The present European Search Report was created for parts of the Application that pertain to the invention for which the search fees have been paid, namely patent claims: [X] None of the additional search fees was paid within the prescribed period of time. The present European Search Report was created for parts of the Application that pertain to the first invention mentioned in the patent claims, namely patent claims: 1, 4-10

European Patent Office

Number of the Application
EP 98 11 7971

LACK OF UNIFORMITY OF THE INVENTION
SUPPLEMENTAL PAGE B

In the opinion of the Search Department, the present European Patent Application does not meet the requirements for uniformity of the invention, and contains several inventions or groups of inventions, namely:

1. Claims: 1 4-10

   Method for generating an image on a color matrix display, with red, green and blue sub-image points that form a visible point, characterized in that the three sub-image points belong to different (at least two) physically adjacent image points (e.g., the first two sub-image points belong to the first physical image point, and the third belongs to the following physical image point).

2. Claim: 2 3

   Method for generating an image on a matrix display, with image regions that are comprised of more than one image point and an effective light distribution, and that can be shifted by one sub-image point in order to shift the effective position.

ANNEX TO THE EUROPEAN SEARCH REPORT TO THE EUROPEAN PATENT APPLICATION NO. EP 98 11 7971

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned European Search report.
The particulars on the family members correspond to the status of the records of the European Patent Office on
The Office is in no way liable for these particulars which are given merely for the purpose of information.

November 5, 1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5113274 A	12-05-1992	JP 1314084 A	19-12-1989
		JP 2584490 B	26-02-1997
EP 0273995 A	13-07-1988	AT 49075 T	15-01-1990
EP 0738089 A	16-10-1996	JP 9178779 A	11-07-1997
		US 5808464 A	15-09-1998
FR 2742910 A	27-06-1997	WO 9723861 A	03-07-1997

EURO FORM P0461

For further details regarding this Annex, see European Patent Office Gazette, No. 12/82